

CLAIMS

What is claimed is:

1. A resonant microelectromechanical scanner, comprising:
a substrate;
an oscillatory body of a first material carried by the substrate and coupled to the substrate for periodic movement;
an optical element carried by the oscillatory body; and
an array of removable masses carried by the oscillatory body and exposed on a surface thereof, the removable masses being of a second material different from the first material, the second material being of a type having a lower vaporization temperature than the first material, wherein the array of removable masses, together with the oscillatory body, forming an oscillatory mass, wherein the oscillatory mass defines the resonant frequency.
2. The microelectromechanical scanner of claim 1 wherein the oscillatory mass is coupled in a configuration that permits the periodic movement to occur about a pivot axis, and wherein the removable masses are grouped in pairs that are symmetrically positioned relative to the pivot axis.
3. The microelectromechanical scanner of claim 2 wherein the number of pairs is greater than one.
4. The micro-electro-mechanical scanner of claim 1 wherein the second material is a metal.

5. The micro-electro-mechanical scanner of claim 1 wherein the second material is an organic polymer.
6. A microelectromechanical device having a desired resonant frequency, comprising:
- a base;
 - a movable body coupled to the base for resonant motion relative to the base about a pivot axis, the movable body having a selected inertia relative to the pivot axis;
 - a support interposed between the base and the movable body and coupled to permit oscillatory movement of the movable body relative to a reference point;
 - and
 - a plurality of exposed masses carried by the movable body and symmetrically positioned relative to the reference point, each of the exposed masses being in an exposed position that provides access for removal, the exposed masses each being positioned to provide a supplemental inertia relative to the pivot axis, wherein the selected inertia and the supplemental inertia together determine a resonant frequency for the device.
7. The microelectromechanical resonant device of claim 6 further comprising:
- a first electrode carried by the movable body; and
 - a reflective material carried by the movable body and positioned to reflect incident light through a periodic scan pattern as the movable body moves relative to reference point.
8. The microelectromechanical resonant device of claim 6 wherein the movable body and the support form an integral body.

9. The microelectromechanical resonant device of claim 6 wherein the exposed masses are formed of a material deposited on an exposed surface of the movable body.
10. The microelectromechanical resonant device of claim 6 wherein the support defines a first pivot axis of the movable body, further comprising a frame interposed between the base and the movable body, the frame being coupled to the base and configured to define a second pivot axis for the movable body substantially orthogonal to the first pivot axis.
11. An apparatus for producing a plurality of resonant optical MEMs scanner from a single wafer, each MEMs scanner having a movable body that moves at a desired resonant frequency and carries one or more removable masses, comprising:
- a first electrical signal source configured for coupling to each respective MEMs scanner while the MEMs scanner is an integral part of the wafer, the first signal source being operative to produce a first input signal for activating the respective optical scanner;
 - a position sensor coupled to the movable body of the respective MEMs scanner and operative to produce an electrical signal indicative of movement of the movable body while the MEMs scanner is an integral part of the wafer;
 - a reference signal source operative to produce a reference signal at the desired resonant frequency;
 - an electronic controller coupled electrically to the position sensor and the reference signal source, the controller being operative to produce an error signal indicative of a difference between a frequency of movement of the movable body and the desired resonant frequency; and

a mass removal apparatus responsive to the electronic controller to remove selected portions of the removable masses while the respective MEMs scanner is an integral part of the wafer.

12. The optical scanner of claim 11 wherein the removable masses are formed from a deposited material on respective exposed regions of the movable masses.

13. The optical scanner of claim 11 wherein the wafer comprises is a semiconductor.

14. The optical scanner of claim 11 wherein the removable masses are formed from an organic polymer.

15. A method of controlling a scanning motion of a MEMs device formed in a semiconductor wafer, comprising the steps of:

while the MEMs device is an integral part of the wafer, activating the MEMs device for periodic motion of a portion of the MEMs device relative to a reference point, the portion having an inertial mass offset from the reference point by a selected distance;

monitoring the periodic motion of the MEMs device;

responsive to the monitored periodic motion of the MEMs device,

identifying a deviation of the periodic motion from a desired periodic motion;

generating an error signal in response to the identified deviation; and

while the MEMs device is an integral part of the wafer and responsive to the error signal, removing a portion of the inertial mass.

16. The method of claim 15, wherein the step of removing the portion of the inertial mass includes removing material from an exposed surface of the portion of the MEMs device.

17. The method of claim 16, wherein the portion includes a material deposited on the exposed surface and wherein removing material from the portion of the MEMs device includes laser ablation of a part of the deposited material.
18. The method of claim 16 further including selecting an amount of the material to be removed in response to the deviation of the periodic motion from the desired periodic motion.
19. The method of claim 16, wherein removing material from the portion of the MEMs device includes thermally removing a part of the material.
20. The method of claim 15 wherein the step of monitoring the periodic motion of the MEMs device includes probing the wafer with a probe station.
21. The method of claim 15 wherein the step of activating the MEMs device for periodic motion of a portion of the MEMs device includes applying an electrical driving signal to the MEMs device.
22. The method of claim 15 wherein the step of monitoring the periodic motion of the MEMs device includes optically detecting movement or position of the portion.
23. A method of controlling a MEMs device formed in a semiconductor wafer, comprising the steps of:
- while the MEMs device is an integral part of the wafer, activating the MEMs device for resonant motion of a portion of the MEMs device relative to a reference point;
 - monitoring the resonant motion of the MEMs device;

responsive to the monitored resonant motion of the MEMs device,
identifying a deviation of the resonant motion from a desired periodic motion;
generating an error signal in response to the identified deviation; and
while the MEMs device is an integral part of the wafer and responsive to
the error signal, varying material properties with a region of the MEMs device in a
manner that changes the frequency of the resonant motion.

24. The method of claim 23 wherein varying the material properties includes
introducing an impurity into a portion of the wafer.

25. The method of claim 23 wherein the MEMs device includes a torsional
member that in part defines a resonant frequency of the MEMs device, and
wherein varying the material properties includes introducing an impurity into a
portion of the torsional member.

26. The method of claim 25 wherein the impurity is a metal.

27. The method of claim 25 wherein the impurity is a chromium.

28. The method of claim 25, wherein introducing an impurity into a portion of
the torsional member includes:

placing an impurity on a surface of the torsional member; and
heating the torsional member.

29. The method of claim 23 wherein the step of monitoring the periodic
motion of the MEMs device includes probing the wafer with a probe station.

30. The method of claim 23 wherein the step of monitoring the periodic motion of the MEMs device includes optically detecting movement or position of the portion.